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Faculty	Science and Technology
Title/Research Topic	**Brain Abnormalities Detection From MRI Images**
Date of RAC	23/09/2020
Date of RRC	13/03/2021
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"Brain Abnormalities Detection from MRI Images"

Ph.D. Workplan

Submitted to

Swami Ramanand Teerth Marathwada University, Nanded

Submitted by

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Under the Guidance of

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Synopsis: Brain Abnormalities Detection from MRI Images

1. A Brief Resume of the Proposed Problem:

Segmentation of digital images involves the extraction of region of interests (ROIs) from the image. The ROIs usually correspond to anatomically meaningful structures, such as organs or parts of organs, or they may be lesions or other types of regions in the image pertinent to the application. The structures may be delineated by their borders, in which case edge detection techniques (such as edge-following algorithms) are used, or by their composition in the image, in which case region-detection techniques (such as texture analysis) are used. Neither of these techniques has been completely successful as fully automated image segmentation methods. Regions often have discontinuous borders or non-distinctive internal composition. Furthermore, contiguous regions often overlap. These and other complications make segmentation the most difficult subtask of the medical image processing problem. Because segmentation is difficult for a computer, it is usually performed either manually or in a semi-automated manner with assistance by a human through operator-interactive approaches. In both cases, segmentation is time intensive, and it therefore remains a major bottleneck that prevents more widespread application of image processing techniques.

2. Introduction:

A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels. Interest in digital image processing methods stems from two principal application areas: improvement of pictorial information for human interpretation; and processing of image data for storage, transmission, and representation for autonomous machine perception..

The significance of Digital Medical Imaging in the modern healthcare has led to the indispensable role of medical image analysis in the clinical therapy. Medical image classification, a fundamental step in medical image analysis, aims to distinguish medical images according to a certain criterion, such as clinical pathologies or imaging modalities. A reliable medical image classification system is able to assist doctors in the fast and accurate interpretation of medical images.

2.1 Medical Imaging Modalities

Medical imaging enables us to see what's going on inside the body without the need for surgery or other invasive procedures. Medical imaging can be used for both diagnosis and therapeutic purposes, making it one of our most powerful resources available for effective care of patients.

Modalities of Digital Medical Images includes-

i. X-ray imaging
ii. Ultrasound (US)
iii. Computed Tomography (CT)
iv. Magnetic Resonance Imaging (MRI)
v. Positron Emission Tomography (PET)
vi. Retinal Photography

MRI can detect a variety of conditions of the brain such as cysts, tumors, bleeding, swelling, developmental and structural abnormalities, infections, inflammatory conditions, or problems with the blood vessels. It can determine if a shunt is working and detect damage to the brain caused by an injury or a stroke. In the further discussion brain tumor as one of the abnormality is considered.

2.2 Need of Image Segmentation

Medical image segmentation has an essential role in computer-aided diagnosis systems in different applications. The vast investment and development of medical imaging modalities listed above, attracts the researchers to implement new medical image-processing algorithms. Image segmentation is considered the most essential medical imaging process as it extracts the ROIs through a semiautomatic or automatic process. It divides an image into areas based on a specified description, such as segmenting body organs/tissues in the medical applications for border detection, tumor detection/segmentation, and mass detection.

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automated manner with assistance by a human through operator-interactive approaches. In both cases, segmentation is time intensive, and it therefore remains a major bottleneck that prevents more widespread application of image processing techniques.

A great deal of progress has been made in automated segmentation in the brain, partially due to the fact that the anatomic structures tend to be reproducibly positioned across subjects and the contrast delineation among structures is often good. In addition, MRI images of brain tend to be high quality. Several software packages are currently available for automatic segmentation, particularly for normal macroscopic brain anatomy in cortical and sub-cortical regions.

Comparison of image segmentation techniques

Algorithm	**Description**	**Advantages**	**Limitations**
Region-Based Segmentation	Separates the objects into different regions based on some threshold value(s).	a. Simple calculations b. Fast operation speed c. When the object and background have high contrast, this method performs really well	When there is no significant grayscale difference or an overlap of the grayscale pixel values, it becomes very difficult to get accurate segments.
Edge Detection Segmentation	Makes use of discontinuous local features of an image to detect edges and hence define a boundary of the object.	It is good for images having better contrast between objects.	Not suitable when there are too many edges in the image and if there is less contrast between objects.
Segmentation based on Clustering	Divides the pixels of the image into homogeneous clusters.	Works really well on small datasets and generates excellent clusters.	a. Computation time is too large and expensive. b. k-means is a distance-based algorithm. It is not suitable for clustering non-convex clusters.
Mask R-CNN	Gives three outputs for each object in the image: its class, bounding box oordinates, and object mask	a. Simple, flexible and general approach b. It is also the current state-of-the-art for image segmentation	High training time

Traditional Segmentation Algorithms	Divides image into k number of homogenous, mutually exclusive clusters – hence obtaining objects	Proven methods, reinforced with fuzzy logic and more useful for real-time application.	Determining cost function for minimization can be difficult.

3. Review of Literature and Development in the Relevant Subject:

The past decade has seen a rapid expansion in the number of studies using medical imaging techniques to investigate various diseases/abnormalities, e.g. brain tumor, autism and schizophrenia.

Among brain tumors, gliomas are the most common and aggressive, leading to a very short life expectancy in their highest grade. Thus, treatment planning is a key stage to improve the quality of life of oncological patients. Magnetic resonance imaging (MRI) is a widely used imaging technique to assess these tumors, but the large amount of data produced by MRI prevents manual segmentation in a reasonable time, limiting the use of precise quantitative measurements in the clinical practice. So, automatic and reliable segmentation methods are required; however, the large spatial and structural variability among brain tumors make automatic segmentation a challenging problem. [1]. A fully automatic brain tumor segmentation method based on Deep Neural Networks (DNNs). The proposed networks are tailored to glioblastomas (both low and high grade) pictured in MR images. By their very nature, these tumors can appear anywhere in the brain and have almost any kind of shape, size, and contrast. These reasons motivate our exploration of a machine learning solution that exploits a flexible, high capacity DNN while being extremely efficient. Here, description of different model choices found to be necessary for obtaining competitive performance. Different architectures based on Convolutional Neural Networks (CNN), i.e. DNNs specifically adapted to image data is explored [2].

Deep Learning (DL) is powerful state of art for medical image processing and analysis. Over past few years, the most popular and efficient approach for medical image analysis are artificial intelligence and DL. To overcome the computational complexity of processing 3D medical scans, 11-layers deep, three-dimensional Convolutional Neural Network for the challenging task of brain lesion segmentation was proposed. DeepMedic is the 11-layers deep, multi-scale 3D CNN for brain lesion segmentation. The architecture consists of two parallel convolutional

pathways that process the input at multiple scales to achieve a large receptive field for the final classification while keeping the computational cost low [3]. Multimodal Brain Tumor Image Segmentation Benchmark (BRATS) generated the largest public dataset available for this task and evaluated a large number of state-of-the-art brain tumor segmentation methods. The results indicate that, while brain tumor segmentation is difficult even for human raters, currently available algorithms can reach Dice scores of over 80% for whole tumor segmentation. Segmenting the tumor core region, and especially the active core region in high-grade gliomas, proved more challenging, with Dice scores reaching 70% and 60%, respectively. An important observation in this study is that fusing different segmenters boosts performance significantly [4].

4. Objectives of Proposed Research and Proposed Hypothesis:

Need of Advanced Technologies

Imaging technology plays vital role in the field of medical science. It helps the specialists to see the interior portions of the body for stress-free diagnosis. During surgical treatment, it helps surgeons to detect the diseased parts instead of opening too much of the body.

Need of Accurate and Automatic Tumor Segmentation

Manual segmentation of brain images is a time consuming. Segmentation of brain volume of 256 x 256 sized brain images takes nearly 2-4 hour and shows 14 %- 22 % differences when executed by different radiologist. Accurate and automatic tumor segmentation is gaining more importance over manual segmentation.

Tumor segmentation from magnetic resonance imaging (MRI) data is an important but time consuming manual task performed by medical experts. Automating this process is a challenging task because of the high diversity in the appearance of tumor tissues among different patients and in many cases similarity with the normal tissues. MRI is an advanced medical imaging technique providing rich information about the human soft-tissue anatomy. There is no need to expose patient to high ionizing radiations.

Types of MRI sequences:

- T1 weighted MRI (T1w)- This allows easy annotation of healthy tissues.
- T1 weighted MRI with contrast enhancement (T1wc)- This makes brain tumor borders more brighter (enhancing tumor).
- T2 weighted MRI (T2w)- edema and core region can be differentiated.
- Fluid Attenuated Inversion Recovery (FLAIR)- whole tumor region can be seen clearly

There are different brain tumor detection and segmentation methods to detect and segment a brain tumor from MRI images. These detection and segmentation approaches are reviewed with an importance placed on enlightening the advantages and drawbacks of these methods for brain tumor detection and segmentation.

5. Methodology to be used and adopted:

Here focus is on automated detection of brain tumor through MRI. The appearance of tumors in MRI images, the grade of tumors and some general information which will be useful in the detection, segmentation and interpretation of brain tumors. An automated brain tumor detection procedure follows some steps which is shown diagram below.

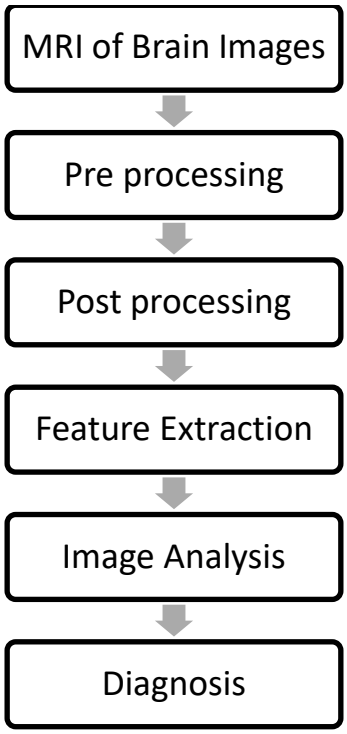

Figure 1: Brain Tumor Detection Steps

Some of the steps involved in brain tumor detection are -

Pre processing: This pre-processing stage is used for reducing image noise, highlighting important portions, or displaying obvious portions of digital images.

Segmentation: Segmentation is the process of partitioning an image to several segments but the main difficulties in segmenting an images are i) Noise, ii) Blur Low Contrast, iii) The bias field (the occurrence of smoothly varying intensities within tissues) , iv) The partial-volume effect

Feature Extraction: Feature extraction is a method of capturing visual content of an image. The feature extraction is the process to represent raw image in its reduced form to facilitate decision making such as pattern classification

6. Importance of study:

6.1 International Status:

Tumor is defined as abnormal growth of tissues. Brain tumor is an abnormal mass of tissue in which cells grow and multiply uncontrollably and unchecked by the mechanism that control normal cells. Grade I brain tumors may be cured if they are identified at early stage bad can be completely removed by surgery. Grade II — The tumor cells grow and spread more slowly than grade III and IV tumor cells. They may spread into nearby tissue and may recur (come back). Some tumors may become a higher-grade tumor. This study will help to detect the tumor at early stage to ensure the recovery of the patients. (World Cancer Research Journal 2019).

6.2 National Status:

According to National health portal of India, The incidence of central nervous system (CNS) tumors in India ranges from 5 to 10 per 100,000 population with an increasing trend. Metastatic brain tumors occur when cancer located in another organ of the body spreads to the brain.40% of all cancers spread to brain. Brain and central nervous system tumors are also the second most common cancers in children, accounts for about 26% of childhood cancers. Magnetic resonance imaging (MRI) is commonly used to help diagnose brain tumors. In some cases a dye may be injected through a vein in your arm during your MRI study.

A number of specialized MRI scan components — including functional MRI, perfusion MRI and magnetic resonance spectroscopy — may help your doctor evaluate the tumor and plan treatment.

7. Proposed Work Plan with Tentative Chapter Scheme

Chapter 1: Introduction

Chapter 2: Literature Review

Chapter 3: MRI Image Pre-processing Techniques

Chapter 4: MRI Image Segmentation

Chapter 5: MRI Image enhancement and filtering

Chapter 6: Experimental Results

Chapter 7: Diagnosis based on the Experimental Results

Chapter 8: Conclusion and Future Scope

8. Year wise plan of work and targets to be achieved

Year 1	**Year 2**	**Year 3**
Performing the Literature Survey to identify the Gaps in Literature	Study of different image segmentation techniques.	Development of Complete System that combines and all the compressed outputs together
Collection of Datasets(Brats, Kaggle, Tata memorial hospital)	Study of Different Deep learning methods/architectures	Experimentation on Various dataset images, Visualization of Result and Discussions on various finding and drawing the final Conclusions
Study and Implementation of Image Segmentation using different clustering algorithm.	Study and implementation of Image segmentation using Deep learning.	Thesis Writing

9. Expected Outcomes:

1. Investigation of suitable segmentation technique for Medical Images (MRI)
2. Development of clustering algorithm technique for segmentation.
3. Region growing (also called region merging) technique for extracting a connected region of the image which consists of groups of pixels/voxels with similar intensities
4. Implementation of different deep learning architecture.
5. Development of the brain image analysis system

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